

A LICHEN SOCIETY OF A SANDSTONE RIPRAP.

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(WITH FIVE FIGURES)

THE ecologic conditions governing the composition of a given lichen society are interesting and instructive, though often difficult to determine with any degree of certainty. The writer has in various papers attempted to trace in a general way some of these conditions, treating a considerable number of societies and attempting to show how the plants are adapted structurally. Among other societies thus studied, there are a number occurring on sandstone, all surrounded by very similar climatic but quite different edaphic conditions. Some of these societies of the sandstones are surrounded by other lichen societies, usually of trees, and show most interesting instances of tension lines and invasions of certain lichen species from one to another of two adjacent societies. Discussions of these societies may be found in the writer's papers concerning the lichen floras of Minnesota and Iowa.

I. DESCRIPTION OF THE RIPRAP.

The lichen society to receive special attention in this paper is peculiar in a number of ways. For some time it has seemed desirable to study other lichen societies of sandstone than those of ledges along streams, and advantage was taken of the first opportunity for such an investigation far from a large stream by taking a society found growing upon rocks removed from their native beds. Before considering the society, it will be in order to state its location and to explain something of the surrounding conditions and antecedents which have made its existence possible. The riprap on which the society occurs forms a brace and a protection for a high grade of the Rock Island railroad, four miles west of Grinnell, Iowa. The rock of which the riprap is constructed is the ferruginous sandstone of the lower Carboniferous, and was obtained at Kellogg, some thirty miles westward on the same railroad. The riprap lies on the north side of roadbed, and is in the form of a wall along the upper part of the grade

and four bracing extensions running downward and away from the track, nearly to the base of the high grade (*fig. 1*). The riprap wall, running parallel to the roadbed and 1.2^m below it, is 60^m long, varies from 1.5 to 2.5^m in perpendicular height, and rises at an angle of 45 to 55° . The four bracing extensions run down the sides of the grade at right angles with the wall above and at an angle of about 30° . The length of the extensions averages about 21^m , and they vary from 2 to 2.7^m in width. A grass-sedge swamp lies to the north of the

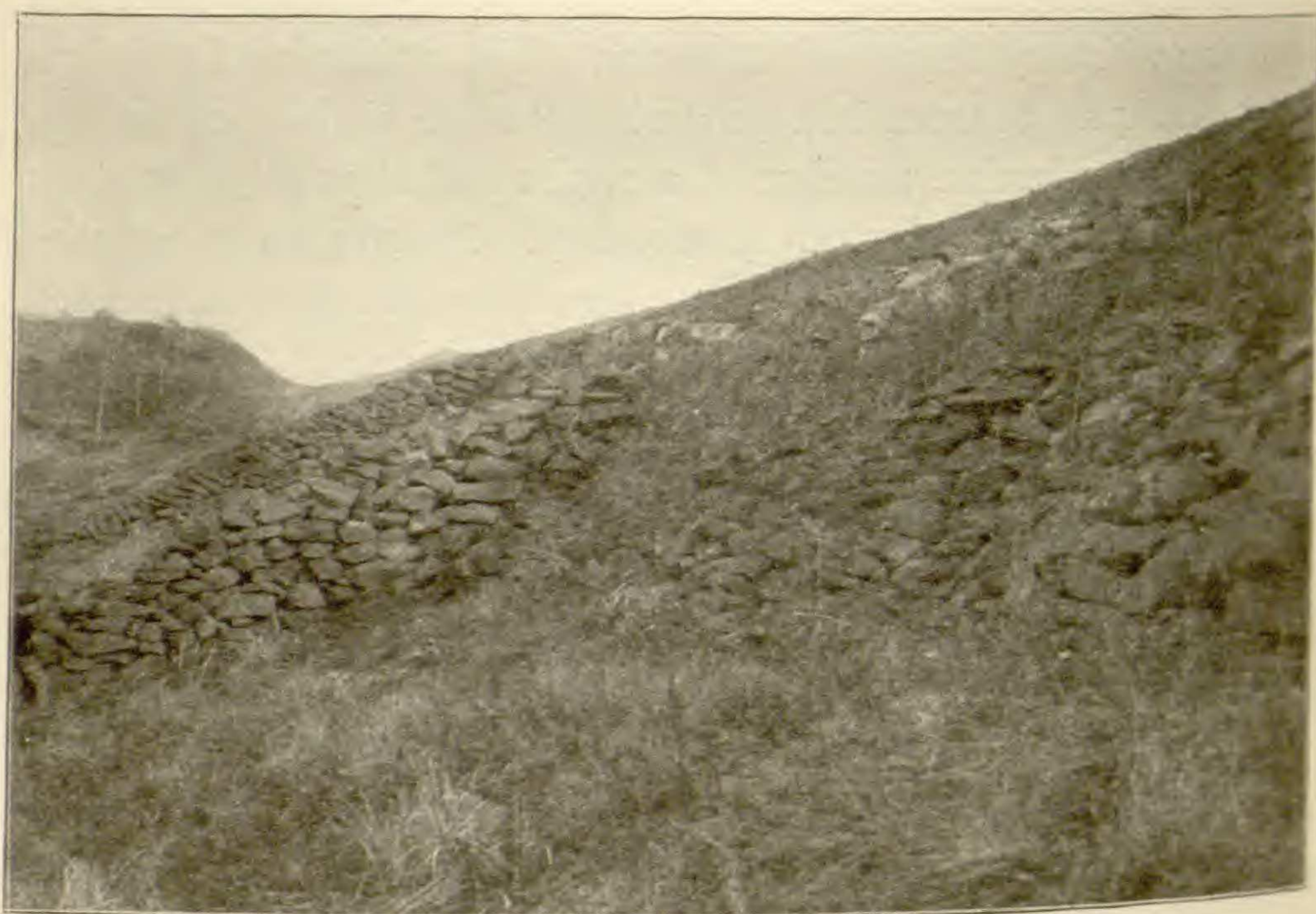


FIG. 1.—View of a portion of the northward-exposed wall and portions of two of the extensions, showing something of the spermatophytic flora and the general plan of structure of the riprap.

society and contains a considerable amount of water in wet seasons. The vertical height of the grade above the swamp level is about 12^m , and the riprap extensions pass from within 1.2^m of the track bed, downward to within 3^m of the swamp level. The riprap was built in 1874 and is thus thirty years old.

II. ECOLOGIC FACTORS.

The conditions as a lichen-bearing substratum are unique in a number of ways. Though the same rocks used for walls under buildings and ten or more years older are apparently sound, the loosely

laid and more exposed rocks of the riprap have weathered considerably and differentially, the rate of weathering depending partly upon position and in part upon the amount of cementing iron contained in each particular piece. In its position away from running water, a portion of the disintegrating sand of the riprap remains on the ground and in the crevices and forms a small amount of soil upon which plants may grow. Again the riprap is partly swamp-bound, with woods some 150^m away. Also there are only two or three boulders near by, the Kansan drift which covers the surrounding country carrying very few at the surface. Thus there are at present and have been since the establishment of the society no lichens, or at least none that can be detected readily, in the region immediately surrounding the society; for one would hardly look for lichens among the plants of the grass-sedge swamp or among the xerophytic spermatophytes of a gravelly railroad bed worked year after year. Hence we have here an isolated lichen society, which has developed to its present condition during the last thirty years, while separated from the nearest lichen society by 150^m.

How each individual species of the society found its way to the spot cannot now be ascertained certainly. Indeed, one well acquainted with lichens might pass the spot without examination, so complete is the isolation of the society and so barren do the rocks appear at first inspection. In fact it is only after an examination of the rocks with a hand lens and a careful survey of the crevices that anything of special interest is discovered. Till recently cut, a group of oaks and other trees were standing about 150^m distant from the riprap, and these trees bore the foliose *Parmelias* and *Physcias*, the fruiticose *Ramalinas*, and the crustose *Placodiums*, *Lecanoras*, and *Rinodinas*. But the trees were young when cut, the largest measuring scarcely more than a foot in diameter and the majority about half this size, and were mere shrubs when the riprap was made, surely not carrying any of these lichens, except perhaps some of the crustose forms. Were trees of good size and bearing lichens immediately surrounding the society, the lichens from the trees would now be gaining a foothold on the riprap blocks, though not so well adapted to the substratum as some other lichens. Were numerous boulders near at hand, another type of lichens might now be less sparingly represented in the

society. But the lichens of the trees 150^m away are on the whole of a type very sparingly represented on the riprap, those of the trees being of the genera mentioned above and very seldom seen on the riprap, and in the main then by different species, while those of the riprap society are mainly a number of crustose species absent from the trees or only sparingly represented on them, and several fruticose species wholly absent from the trees. All of this will appear more plainly after a list of species of the society under consideration is given. The causes which have led to the possession of the riprap by certain types of lichens may also be discussed to better advantage later, the intention here being merely to bring out the fact that proximity has not enabled the lichens of the trees to gain possession of the rocks in face of certain unfavorable conditions, and that other types have consequently gained the ascendancy.

As to moisture, the swamp brings an abundance of soil moisture, especially toward the lower ends of the riprap extensions. Thus at certain times, as in wet seasons and after rains, the fruticose *Cladonias* grow well in the somewhat shaded and moist openings between the blocks of riprap, and pass into the desiccated condition without injury whenever the moisture becomes deficient. Since the soil moisture does not pass upward through the loose riprap to any great extent, and the small blocks retain very little moisture, the upper surface of the sandstone blocks becomes drier than would the upper surface of a similarly exposed solid wall or natural exposure of the same kind of rock. Accordingly the conditions on the upper surfaces of the extensions are quite xerophytic, especially toward the upper portion of each extension where farthest removed from the swamp and where the vertical height of the extensions averages about 1.8^m. Passing downward on the upper surface of the extensions, as the height of each one gradually decreases and the soil becomes more moist, the soil moisture works upward through the riprap blocks more and more, so that the conditions become gradually less xerophytic. Passing to other considerations for the present, the change in lichen species upon the upper surface, resulting from the varying ecologic conditions, will receive attention below.

The conditions determining the composition of the lichen society are plainly quite different, surely drier and doubtless on the whole

somewhat less varied than those affecting the seed-plants surrounding the lichens. Yet for those more accustomed to the considerations of societies of these higher plants, a brief statement of the types of seed-plants will be more illuminating than would a mere statement of physiographic conditions and the corresponding structural adaptations of the lichens. So although the conditions affecting the lichens are somewhat different, we will no doubt be able to consider the lichen society more intelligently after such brief view of the higher plants. On the upper surface of the extensions and along the northward-facing riprap wall, the xerophytic conditions are plainly seen in the few scattered seed-plants, including *Onagra biennis*, *Lepidium intermedium*, *Ambrosia artemisiaefolia*, *Cassia chamaecrista*, *Hordeum jubatum*, *Polanisia trachysperma*, *Polygonum scandens*, *Verbascum Thapsus*, and *Cenchrus tribuloides*. The same xerophytes occur on the dry gravel of the road bed with *Equisetum arvense*, *Chenopodium Botrys*, and one or two others; and in passing downward one encounters dry meadow, wet meadow, and grass-sedge swamp conditions, all in the few meters, the hydrophytic flora of the swamp showing a number of large grasses and sedges, *Cicuta maculata*, *Typha latifolia*, *Alisma Plantago*, *Scirpus lacustris*, some forms of *Sagittaria*, and a number of fresh water algae in the limited areas where water stands a larger part of the time.

III. COMPOSITION OF THE LICHEN SOCIETY.

That such rapid transition in seed-plant flora should be accompanied by somewhat similar conditions in the lichen flora would be expected; but the riprap does not extend down to the swamp, and the lichens either do not grow on the soil, or when they do they have in their rhizoids poor means for seeking moisture as compared with the somewhat fleshy and deep-growing roots of some of the xerophytic seed-plants named above. Hence the lichens are not so much affected by the conditions as to soil moisture as are the seed-plants. Accordingly the moisture-loving *Collemas*, *Leptogiums*, and *Pannarias* are entirely absent. The extreme xerophytic adaptation as to lichen flora is shown in *Biatora myriocarpoides*, which grows abundantly on the driest portions of the upper surfaces of the riprap extensions, this plant representing in the more xerophytic lichen society what the

xerophytic seed-plants named above do in the spermatophytic society. The lichens composing the society, naming the genera in the order of the importance of one or more of their species as floral elements of the society, are as follows:

Biatora myriocarpoides (Fr.) Tuck. (*Lecidea salvicola* Flt.), the most common lichen of the society, and most abundant on the driest and most exposed portions of the riprap extensions; appearing as dark stains on the rocks, the nature of which can only be ascertained with hand lens.

Bacidia (*Biatora*) *inundata* (Fr.) Kbr., replacing the last above to some extent in the more moist and shaded portions of the society, both on rocks and soil, the plant being as the name indicates somewhat hydrophytic in nature. This species also occurs sparingly mingled with the last in quite dry portions of the upper surface of the riprap extensions, where the thallus is more scanty than in its more natural habitat. The two plants, where occurring together, are very difficult to distinguish macroscopically.

Cladonia mitrula Tuck., on earth and rock along the northward-facing wall; frequent; rarely on the extensions.

Cladonia cariosa (Ach.) Spreng., on soil from disintegrated and somewhat shaded rock; rare.

Cladonia cristatella vestita Tuck., on more or less disintegrated rock and usually on the lower and more moist portions of the riprap where more or less shaded; rare.

Cladonia furcata (Huds.) Schrad.; only one well developed plant seen and that in a well protected and moist place on the east basal part of the upper portion of one of the riprap extensions.

Cladonia fimbriata coniocraea (Flt.) Wainio, in shaded or somewhat exposed places and more often toward the moist basal portions and sides of the riprap extensions; quite frequent; hitherto reported in Iowa under the varietal name *tubaeformis* Fr., which has also included the next.

Cladonia fimbriata apolepta (Ach.) Wainio, with the last, but rare and difficult to distinguish.

Cladonia fimbriata simplex (Weis.) Wainio, in well shaded spots; rare; new to Iowa, and easily confused with the second below, from which it differs in its more slender habit, its more soresiate condition, and its tendency to pass into the irregularly cylindrical forms of the last two above.

Cladonia pyxidata neglecta (Flk.) Schaer., in more or less damp and shaded places on disintegrating rock; frequent.

Cladonia pyxidata chlorophaea (Spreng.) Flk., in more or less shaded places toward the base of the riprap extension; rare. These two varieties have not previously been recognized in Iowa collections.

Cladonia gracilis dilacerata Flk., on shaded or northward-facing and more or less disintegrated surfaces: rare

Cladonia gracilis dilatata (Hoffm.) Wainio, occurring with the last; rare. These forms have not been recognized before in Iowa, but have been included under the partial synonym var. *hybrida* Fr.

Stereocaulon paschale (L.) Ach. (?), on exposed and little disintegrated rock, but better developed toward the basal, damp, and more disintegrated portions of the riprap extensions. Small and perhaps as near *S. coralloides*. A northern species new to Iowa. Frequent, but only once seen in fruit.

Lecanora cinerea (L.) Sommerf. (?), on exposed and comparatively firm rock; once seen and sterile.

Lecanora muralis saxicola (Poll.) Schaer., occurring as the last; once seen and sterile.

Placodium aurantiacum (Lightf.) Naeg. and Hepp, on firm rock of the riprap wall; once seen.

Placodium vitellinum (Ehrh.) Naeg. and Hepp, on firm and exposed rock; rare.

Placodium cerinum (Ehrh.) Naeg. and Hepp (?), occurring as the last and rare; spores immature.

Acarospora (*Lecanora*) *cervina fuscata* (Schrad.) Fink; once seen on firm rock of the northward-facing wall.

Acarospora (*Lecanora*) *xanthophana* (Nyl.) Fink, on exposed and firm rock; once seen and sterile.

Rinodina sophodes (Ach.) Kbr.; once noted on a firm and exposed spot where the rock was especially hard because of the presence of a large amount of iron. In rapid field work the plant is not easily distinguished from the first of the list and may be somewhat more common than appears at present.

Lecidea enteroleuca Ach., on exposed rock, rare and easily passed over for the first of the list.

Verrucaria muralis Ach., on exposed and comparatively firm surfaces; rare.

Verrucaria fuscella Fr., occurring with the last and more rare.

Parmelia Borreri Turn., on quite firm, but somewhat damp and shaded rock; rare and sterile.

Parmelia conspersa (Ehrh.) Ach., occurring as the last and also very rare and sterile.

Physcia stellaris (L.) Tuck., once seen on the shaded, northward-exposed wall.

Ramalina calicaris (L.) Fr., on damp surfaces toward the base of the northward-facing wall; once seen.

Dermatocarpon (*Endocarpon*) *pusillum* Hedw., on somewhat shaded rocks of one of the riprap extensions; very rare.

Besides the thirty forms listed above, there occurs commonly a sterile thallus somewhat like that of *Amphiloma* (*Pannaria*) *lanuginosum* (fig. 2). This thallus is without distinct cortex and seems nearly as rudimentary as that of *Amphiloma*, but is verrucose rather

than finely granular, is chinky or subareolate and not so distinctly sorediate as the thallus of *Amphiloma*. This unknown thallus seems also to resemble that of *Urceolaria scruposa* in microscopic structure, but it is not so well developed. This lichen is a very conspicuous feature of the society and is common toward the basal, damp ends of the riprap extensions, especially the eastward two. It also extends upwards to the upper end of the extensions, but in passing upward is confined more and more to the damp sides and crevices.

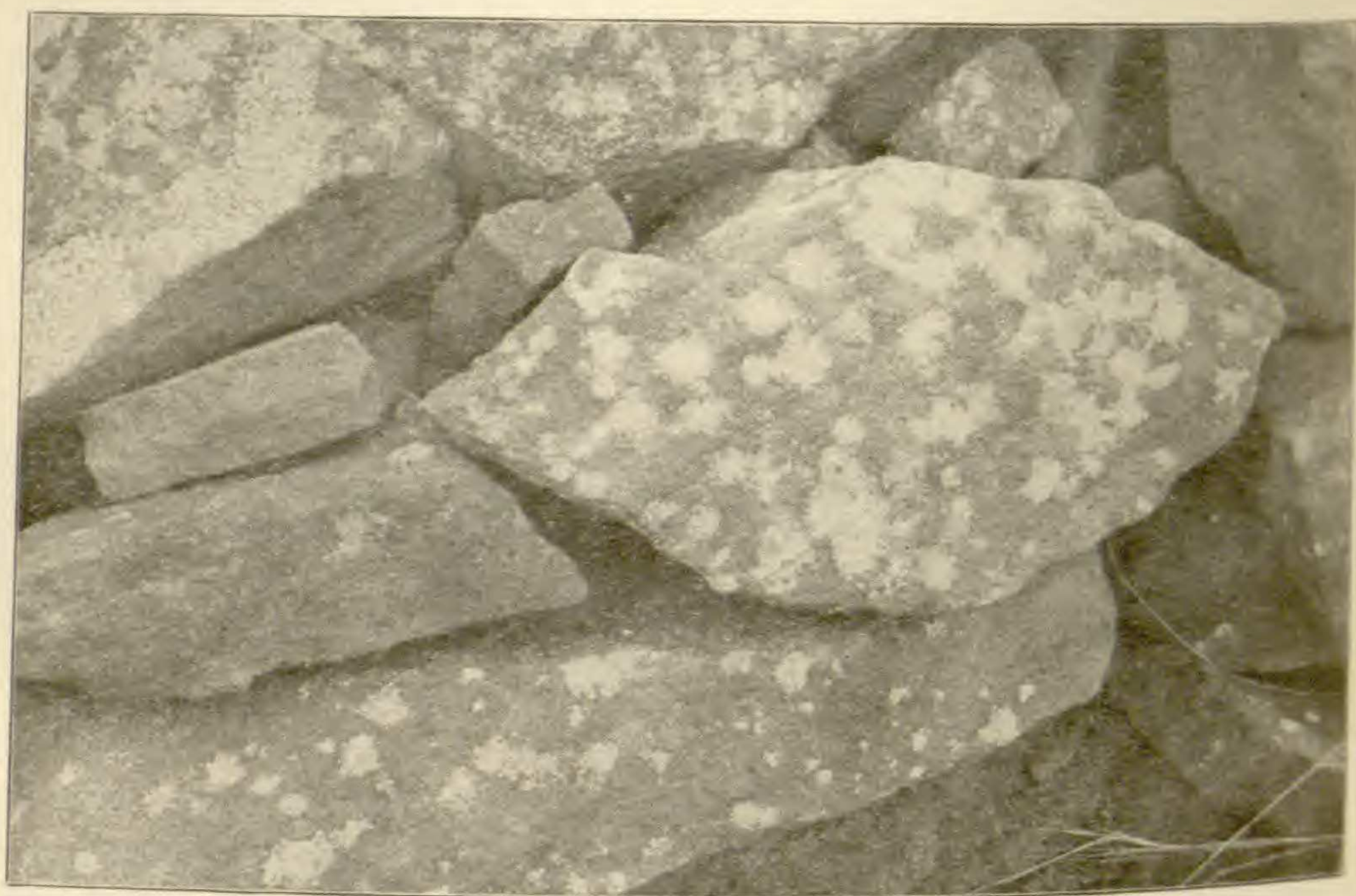


FIG. 2.—Blocks of riprap at the side of one of the extensions, showing thalli of the *Amphiloma*-like lichen.

IV. TYPES OF THALLI REPRESENTED.

As to types of lichen thalli in the society, we have in the main the rudimentary type with leprose or finely granular surface and devoid of cortex, and the fruticose cylindrical type with protective and strengthening pseudocortex of mostly parallel and longitudinal hyphae. Other types, as the foliose and the areolate or squamose corticate-crustose forms, appear but rarely and do not form a conspicuous portion of the society. The first type of thallus is represented by the first two lichens of the list, and by the *Amphiloma*-like thallus. The first, *Biatora myriocarpoides*, was doubtless the first lichen to

gain possession of any considerable portion of the riprap and is still abundantly maintaining itself in the drier places where the rock is not disintegrating so rapidly. The second of the list, *Bacidia inundata*, occupies similar but moister surfaces of both wall and extensions, its thallus varying considerably according to conditions of moisture, being well developed in the moist places where the species is usually found, but almost wanting in the dry, exposed places. These two species seem to prevail here instead of the better developed types of crustose thalli, because the rock disintegrates too rapidly for the possibility of extensive establishment of the better developed thalli. The better developed crustose thalli are the forms that prevail on such hard rocks as the Sioux quartzite, or as we shall see shortly, on riprap of similar sandstones where drier and disintegrating more slowly, and are represented in the present society by the rare specimens of *Lecanora*, *Placodium*, and *Acarospora*. A hasty study of the similar thalli of the *Biatora* and the *Bacidia* above named scarcely reveals definitely why one should be more xerophytic than the other, though the thallus of the former is on the whole more closely adnate than that of the latter. However, the *Biatora* shows under the microscope a more pronounced xerophytic adaptation in the somewhat tougher, more lecideine condition of the hypothecium and exciple, and in the somewhat better development of the paraphyses.

The cylindrical type of thallus is represented by the *Cladonias* and by the single species of *Stereocaulon*. These lichens thrive best in the society where they may have a fair supply of moisture and shade, when somewhat protected from the wind, and on soil, or on rocks somewhat disintegrated. The conditions as to moisture, shade, and protection from wind are all fairly well met in the crevices toward the base of the northward-facing wall, in the openings between riprap blocks, and in certain places protected more or less by a projecting block. As has been stated, these plants are often able to maintain themselves in spite of disintegration, and when the product of disintegration remains *in situ* are actually invigorated by the process and finally come to rest on a sandy soil

V. VARYING ECOLOGIC CONDITIONS AND RESULTING DISTRIBUTION OF MEMBERS OF THE SOCIETY.

Plainly the conditions on the upper surface of the riprap extensions become less xerophytic in passing downward toward the swamp below, and also because the riprap is not so high toward the lower ends. The gradual increase in amount of moisture influences perceptibly the distribution of the lichens upon the riprap extensions. *Biatora myriocarpoides* is more prevalent toward the upper portion of each extension, not because it is poorly adapted to the more moist conditions farther down, but because in the latter position the plant must compete with others as well or better adapted to the position. The *Amphiloma*-like lichen, in its distribution upon the riprap, shows a most delicate adjustment to conditions of moisture. At the lower ends of the extensions it is more common, rises to the exposed surface and forms a conspicuous portion of the flora; while in passing upward, it becomes less and less conspicuous, and toward the upper ends is scarcely noticeable on the exposed upper surfaces of the blocks, but is frequently seen in crevices and increasingly so the deeper one may be able to look downward through the loose riprap. *Bacidia inundata* occurs on the northward-facing wall and competes with the last for position upon the upper surface toward the lower ends of the extensions, but from its inconspicuous character and less frequent occurrence does not form so conspicuous a portion of the society. The *Cladonias* also are most delicately responsive to moisture conditions in their distribution in the society (fig. 3). Toward the lower ends of the extensions, they rise to the exposed surfaces of the riprap, and in passing upward are more and more inclined to seek the more moist and shaded positions in the cracks between the blocks of riprap and along the sides of each riprap extension or toward the base of the wall. It has already been noted that less moisture reaches the upper surface toward the upper ends where the extensions are higher, and it may be added here that these same surfaces are more exposed to the drying winds than those at the lower ends of the extensions and nearer the level of the general surrounding surface, this condition also influencing the distribution of the *Cladonias*.

VI. ORIGIN OF THE SOCIETY.

Just how each species arrived at the spot or when it came is not easily stated. It is supposed that fragments of lichens carried in the wind fall in places favorable for growth.¹ Few of the lichens of the society are conspicuously sorediate, but it is probable that nearly all of them arrived at the spot from some place near at hand, through purely vegetative dissemination. In this way the species may even



FIG. 3.—Somewhat shaded and disintegrated riprap blocks near ground on north side on an extension, with *Cladonia fimbriata* scattered throughout the field, *C. furcata* at the left, *C. cristatella vestita* in the crevice at the forefront, and a few white thalli of the *Amphiloma*-like plant.

have arrived from stations quite remote from their present position. Taking into account the statements given above as to the scarcity of lichens in the circle of 300^m in diameter and immediately surrounding the society, this supposition seems quite probable, at least for quite a number of the species. Yet the inconspicuous, crustose species may have come from a few Kansan boulders recently removed. Thus the *Biatora* and the *Bacidia* may have reached their present

¹ PEIRCE, G. J., The nature of the association of alga and fungus in lichens. Proc. Calif. Acad. Sci. III. 1:213. 1899.

habitat, and the same may be stated regarding the rarer crustose members of the society, such as the Lecanoras, the Placodiums, the Acarosporas, the Verrucarias, the Rinodina, and the Lecidea. Yet a few of these crustose forms may have come from the trees some 150^m away, some of the trees no doubt being old enough to bear these lichens at the time when the riprap was built or shortly after. These species are the first and the last Placodium of the list, the Rinodina, and the Lecidea. As to the Cladonias, there are not any conspicuous Cladonia-bearing substrata within a mile, except the loess and Kansan drift of railroad cuts, on which the first Cladonia of the list is very common. However, all of the Cladonias except *C. jurcata* have been found within a few miles of the society, and in all probability arrived from various places not far away. The northern Stereocaulon, not known elsewhere in Iowa, doubtless originated in the society through fragments of thalli brought to the spot on railroad cars, and very probably on ties or telegraph poles. It is not so common a member of the society as a number of the similarly constructed Cladonias, and is usually found on the more solid rocks, the more disintegrated spots having been previously occupied by other lichens or mosses, and the rocks on which it occurs not having had time to disintegrate conspicuously since its advent into the society. The fact that the Stereocaulon (*fig. 4*) is almost uniformly sterile may indicate either that it has only recently gained access to the society, or that it is poorly adapted to the climatic conditions of the region. Also the position of this species on the northward exposure is worthy of note. The Ramalina, the Physcia, and the first Parmelia doubtless came as fragments from trees from one to several miles away, unless these rare members of the society may be thought to have come from fragments blown from the trees some 150^m away, since the trees became large enough to bear these species.

Before leaving this subject it must be pointed out that it is by no means a matter of chance what species will reach such an isolated lichen society and survive. But the matter is determined in such an instance largely by adaptability and early access before the substratum is occupied. As has been noted elsewhere, in instances where rock-lichen societies are adjacent to tree-lichen societies, the lichens of the trees, though scarcely so well adapted to the rocks,

because of proximity, get possession often of considerable portions of the rocky substratum. Excepting the *Stereocaulon*, there seems to have been in the present instance a pretty nearly equal struggle for place in the society, those lichens that are best adapted to the ecologic conditions gaining the ascendancy, and entirely or nearly completely crowding out those less well adapted. That gaining possession is by no means a matter of pure chance will appear in the discussion next below of an adjacent society of a southward exposed riprap.

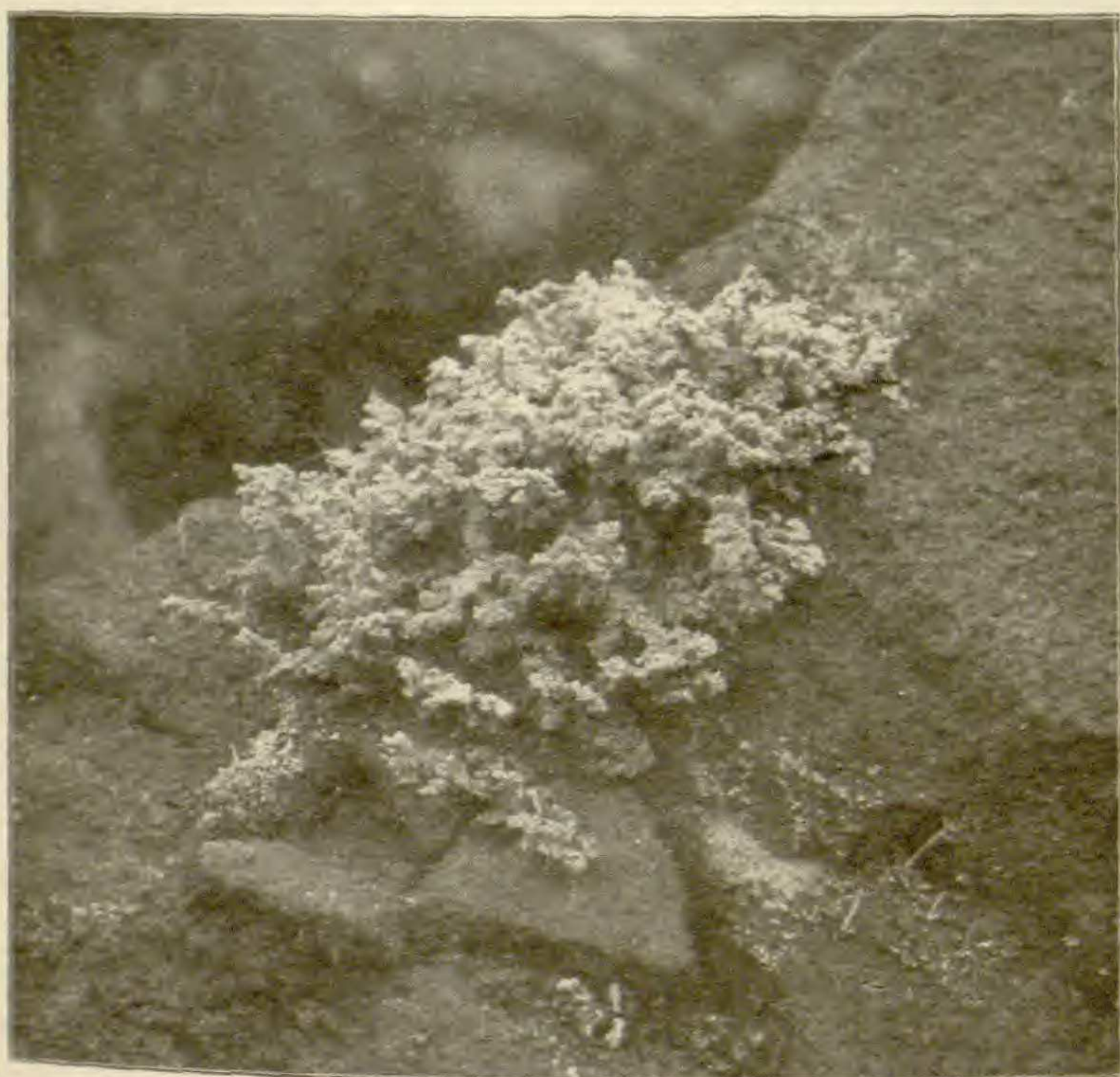


FIG. 4.—*Stereocaulon paschale* on a riprap block on the upper surface and toward the base of one of the extensions.

The *Amphiloma*-like thallus has been purposely omitted from these considerations of origin of the floral elements of the society, since no very definite statement can be made till the species is ascertained.

VII. COMPARISONS WITH OTHER SIMILAR SOCIETIES.

A. *The society of a neighboring riprap.*

There are a number of ripraps at various places along the south side of the railroad bed, and all of these have been examined, as well as others on the north side, the one selected for the present study

being by far the most extensive and the best one for such an investigation. For a comparison of the effect of north and south exposures, we may select a smaller riprap, consisting of a single extension, and lying directly across the track from the one on which occurs the society studied above. Indeed, the plants of the single extension on the south side of the track might perhaps be considered a portion of the society on the north side, but it was thought a separate consideration of them would better show the marked difference in character of the flora. The single extension is of about the same length and width as each one of the four on the north side of the track and makes about the same angle. The land to the south of the track is a low meadow with conditions distinctly less moist than in the swamp to the north. Yet more pronounced is the drying effect of southward exposure, and altogether we have distinctly more xerophytic conditions on this single riprap extension on the south side of the track. Plainly less shade is to be found on the southward exposed extension, and as a result of drier conditions the riprap blocks are much less disintegrated than those on the north side. A discussion of the species of lichens on the riprap south of the railroad track will demonstrate a remarkably nice adjustment between lichen structures and ecologic conditions. The species are as follows:

Acarospora xanthophana (Nyl.) Fink, scarcely infrequent; *A. cervina fuscata* (Schr.) Fink, frequent; *A. cervina cinereoalba* Fink, frequent; *Biatora myriocarpoides* (Fr.) Tuck., rare; *Buellia myriocarpa* (DC.) Mudd, frequent; *Verrucaria fuscella* Fr., frequent; *Lecanora muralis* Ach., infrequent; *L. subfusca* (L.) Ach., rare; *Placodium cerinum* (Ehrh.) Naeg. & Hepp, scarcely infrequent; *P. vitellinum* (Ehrh.) Naeg. & Hepp, rare; *Parmelia conspersa* (Ehrh.) Ach., once seen in a somewhat protected spot; *Cladonia fimbriata coniocraea* (Flt.) Wainio, once seen in a protected and shaded spot.

Besides the above, the *Amphiloma*-like plant is sparingly found on this southward-exposed extension, occurring in shaded spots and especially toward the base, where it is sometimes in more exposed positions. Comparing the lichens of the list above with those of the list for the northward-exposed riprap across the track, we find that the general structure of the plants in the two societies is very different. *Biatora myriocarpoides*, abundant on the north side, is rare on the south side; and the *Acarosporas*, each once seen on the north side, are all frequent on the south side. In the more xerophytic conditions of

the southward exposure, *Buellia myriocarpa* has in part replaced the *Biatora*. The better adaptation of the *Buellia* appears in the greater tendency toward disappearance of the thallus and the better development of such protective structures as exciple, hypothecium, and paraphyses. The *Biatora* is further replaced by the *Acarosporas*. This is due to two causes. Primarily, the disintegration being slower on the drier southward-exposed riprap, the more highly developed thalli of the *Acarosporas* have time for development and the production of apothecia on the more permanent rock surfaces, and are consequently frequent and often fruited. Secondly, with their well-developed upper cortices the *Acarosporas* are even more able to endure extreme xerophytic conditions than is the *Biatora*. Also *Lecanora muralis*, once seen on the north side, was noted several times on the south side, where thalli with well developed cortices are better adapted to the conditions. Response to conditions is beautifully shown in that while *Cladonias* are common enough on the moister and more shaded north side, only a single specimen could be found on the south side. Also the total absence of the *Stereocaulon* from the southward exposure is quite significant, especially when we recall that it occurs commonly in quite exposed places a few meters away on the north side. Finally, the response of lichens to conditions of environment, as shown here, is quite remarkable and fully justifies the detailed attention to a limited area.

B. The society of the sandstone ledges near Boone, Iowa.

The types of lichen structure found in the societies of other sandstone exposures studied in Iowa and Minnesota have been quite different. The places studied have been ledges along streams, which have for the most part either carried away the loose sand as fast as the rocks were disintegrated, or frequently subjected it to inundation, which few foliose or fruticose lichens will endure. In such societies, almost the only *Cladonias* found have been those growing on the faces of the ledges, while in the present society some of the products of erosion have remained to make a soil in which these lichens could grow. The study of a ledge along a stream was recently carried out more completely at the "Ledges" (fig. 5) in Boone county, Iowa, than the writer has done elsewhere; and while the study of the col-

lection made at the "Ledges" is not yet completed, enough has been done so that data for comparison are at hand. The "Ledges" have an extent of about two miles along a tributary of the Des Moines river and are fully 15^m high in some places. They are well shaded in many places and bear a higher plant flora quite different from that about the society especially studied above, and including such moisture-lovers as *Camptosorus rhizophyllus*, *Woodsia obtusa*, *Asarum canadense*, *Impatiens aurea*, *Anemone quinquefolia*, *Arisaema Dracontium*, *Adicea pumila*, *Aralia racemosa*, *Conocephalus conicus*, and a species of *Grimaldia* or *Preissia*; while the conditions at other points are more xerophytic and bear a number of ferns, composites, and trees or shrubs. The lichen species of the "Ledges" are for the most part quite widely distributed upon the rocks, so that the whole number recorded is about the same as for the riprap. The list is as follows:

Usnea barbata Fr., infrequent; *Ramalina calicaris farinacea* (L.) Fr., frequent; *R. calicaris fastigiata* (Pers.) Fr., infrequent; *Parmelia Borreri* Turn., common; *P. crinita* Ach., frequent; *P. caperata* (L.) Ach., infrequent; *Physcia pulverulenta* (Schreb.) Nyl., infrequent; *P. speciosa* (Wulf.) Nyl., rare; *Peltigera canina* (L.) Hoffm., frequent; *P. canina spuria* (Ach.) Tuck., rare; *Senechoblastus* (Collema) *nigrescens* (Ach.) Stizenb., rare; *Collema pulposum* (Bernh.) Ach., rare; *Leptogium chloromelum* (Sw.) Nyl., infrequent; *Pannaria nigra* (Huds.) Nyl., common; *Amphiloma* (*Pannaria*) *lanuginosum* (Ach.) Nyl., abundant; *Acarospora* (*Lecanora*) *fuscata oligocarpa* Nyl., rare and new to Iowa; *Lecanora muralis* (Schreb.) Schaer., rare; *Placodium aurantiacum* (Lightf.) Naeg. & Hepp, frequent; *P. cerinum* (Ehrh.) Naeg. & Hepp, infrequent; *P. vitellinum* (Ehrh.) Naeg. & Hepp, frequent; *P. citrinum* (Hoffm.) Leight., rare; *Pertusaria velata* (Turn.) Nyl., rare; *Urceolaria scruposa* Ach., rare; *Cladonia mitrula* Tuck., common; *C. caespiticia* (Pers.) Flk., rare; *C. pyxidata chlorophaea* (Spreng.) Flk., frequent; *Bilimbia* (*Biatora*) *trachona* (Flt.) Fink, rare; *Buellia spuria* (Ach.) Arn., rare; *Dermatocarpon* (*Endocarpon*) *pusillum* Hedw., common; *Verrucaria muralis* Ach., common; *V. nigrescens* Pers., frequent; *V. viridula* Ach., rare and new to Iowa; *V. fuscella* Fr., rare.

A comparison of the list above with that for the riprap shows little resemblance. The most striking difference is the occurrence of the shade- and moisture-loving lichens in the society at the "Ledges," which are absent from the riprap society. These shade-loving lichens are the *Collemas*, the *Leptogium*, the *Pannaria*, and the *Amphiloma*. The next most conspicuous difference is that on the

solid and less rapidly disintegrating surfaces at the "Ledges," the somewhat better developed crustose thalli, as the *Lecanoras*, the *Placodiums*, the *Pertusaria*, the *Urceolaria*, and the *Buellia*, have to some extent replaced the less differentiated thalli such as the first two of the list for the riprap. Because the disintegrating sandstone of the "Ledges" falls to the ground and is covered with water



FIG. 5.—Portions of the "Ledges" on both sides of the stream, showing general features and spermatophytic flora.

and partly carried away in high water, the *Cladonias* appear only on the sandstone of the ledge faces and are comparatively rare. The more frequent occurrence of the foliose *Parmelias* and *Physcias* and the fruticose *Ramalinas* at the "Ledges" is due partly to the more shaded and moist conditions, and in part to the presence of surrounding trees, from which they may easily wander to the rocks. The above comparison of the two societies is the more interesting when it is stated that both are growing upon the ferruginous sandstone of the same geological horizon, and that the differences noted

are not due in any degree to difference in rock composition, but entirely to other ecologic factors.

C. Some other similar societies.

The lichen societies of various other sandstones differ somewhat from either of the two considered above. Of those hitherto considered, only a single one, that of the Sioux quartzite at Pipestone, Minnesota, is isolated in such a way as to show no tension lines or admixture of elements that so frequently intrude themselves from other adjacent lichen societies. The lichens that have established themselves here are a number of *Acarosporas*, *Placodiums*, *Lecanoras*, *Rinodinas*, and *Buellias*. These lichens in general have strictly crustose thalli, well developed and variously chinky, verrucose, and areolate, and some of them at least a well developed upper cortex. With these, two foliose but closely adnate *Parmelias* and two similar *Physcias* occur here and there in the society, but do not form a conspicuous portion of it. Much of the beautiful wind polishing of the quartzite was surely done at latest before the Wisconsin stage of the Pleistocene, or shortly after the retreat of the Wisconsin ice, and the writer finds the lichens growing on the smoothly polished surfaces, which are as much polished below the lichens as elsewhere. Thus there has been no visible change in the surface of the quartzite since the advent of the present lichen society, and these lichens with well developed thalli have had an abundance of time in which to become established upon the hard surfaces. There is no doubt but that these species may reach an advanced age upon the quartzite, becoming much older than is possible upon the more rapidly eroding ferruginous sandstone of the riprap, and the finding of all the species in good fruit upon the quartzite is quite conclusive evidence of considerable age. No doubt many of these lichens of the quartzite were growing when the riprap was built. Yet we find mainly the same species upon the southward exposed riprap extension, and this shows that such thalli may become established upon the softer sandstone in a comparatively short time.

² FINK, B. Contributions to a knowledge of the lichens of Minnesota. V. Lichens of the Minnesota valley and southwestern Minnesota. Minn. Bot. Studies 2:284. 1899.

Neither upon the softer sandstone nor upon the harder quartzite has the writer been able to observe any certain evidence of the protection which the lichens have afforded the rocks against wind or other atmospheric agencies, though other observers find such evidence elsewhere on rocks of the same kind.³ But whether the acidic action of the lichen thalli upon the rocks, or the climatic, erosion-producing agencies acting upon the surrounding rocks causes the more rapid disintegration, in the end the two factors together act on the softer ferruginous sandstone with comparative rapidity; and as compared with the lichen population of the quartzite, that of the sandstone is quite transient, lichen thalli or portions of thalli disappearing and becoming replaced, except upon the southward exposed extension, more rapidly than the better developed thalli can become established and produce fruit. So it happens that when lichens having the better developed thalli are found, as they rarely are, in the society especially considered in this paper, they are likely to be sterile; while those with less differentiated and apparently more rapidly developing thalli are the ones that are common and well fruited. The fruticose species, as the *Cladonias* and the *Stereocaulon*, are rather rarely established upon the firmer and more exposed rocks. In their more or less shaded and moist habitat in the holes in the riprap, or in protected places about the basal blocks, these fruticose species are able to maintain themselves in spite of disintegration, the wind not blowing them away as is the fate of the smaller thalli on the more exposed surfaces, as soon as these thalli and the atmospheric agencies together disintegrate the rocks sufficiently. Finally, any of the fruticose forms that attempt to gain a foothold on the more exposed surfaces are probably even more likely to be blown away as disintegration proceeds than are the crustose forms, though the rhizoids of the former penetrate the rocks to greater depth than do the hyphal rhizoids of the latter.

The lichen societies of the Saint Peter sandstone along the Mississippi River at Minneapolis and south of McGregor, Iowa, have been considered in a previous paper⁴, and are quite different from the one discussed chiefly in this paper; and the same may be said of the

³ SHIMEK, B, Living plants as geologic factors. *Proc. Iowa Acad. Sci.* 10 : 42. 1902.

⁴ FINK, B., Notes concerning Iowa lichens. *Proc. Iowa Acad. Sci.* 5 : 180. 1897.

society of the similar Jordan sandstone near Mankato, Minnesota.⁵ However, these last three societies were not so exhaustively studied as the first three considered, and a further examination would bring to light some of the less conspicuous members of the societies and decrease the apparent differences.

VIII. CONCLUSION.

The facts stated show clearly some very evident adaptations in lichen thalli, and as disintegration is going on with comparative rapidity at the spot where the society is found, the data herein established will be found useful in future studies. Finally, it may appear that undue attention has been given to a society covering a limited amount of surface. However, as the writer has stated elsewhere,⁶ it is impossible to deal with the details of the ecologic distribution of lichens over a large area, and he has purposely chosen to restrict himself, as in this instance, so that certain minute details might receive attention.

Thanks are due Dr. L. H. Pammel for a photograph of the "Ledges."

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⁵ FINK, B., Contributions to a knowledge of the lichens of Minnesota: V. Lichens of the Minnesota valley and southwestern Minnesota. Minn. Bot. Studies 2: 301. 1899.

⁶ FINK, B., Ecologic distribution an incentive to the study of lichens. The Bryologist 5: 40. 1902.